# Technology Readiness Assessment of Department of Energy Waste Processing Facilities


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2007 Technology Maturity Conference

Virginia Beach, Virginia

September 11-13, 2007

| Report Documentation Page | | | *Form Approved* *OMB No. 0704-0188* |
|---|---|---|---|
| Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. | | | |
| 1. REPORT DATE **SEP 2007** | 2. REPORT TYPE | | 3. DATES COVERED **00-00-2007 to 00-00-2007** |
| 4. TITLE AND SUBTITLE **Technology Readiness Assessment of Department of Energy Waste Processing Facilities** | | | 5a. CONTRACT NUMBER |
| | | | 5b. GRANT NUMBER |
| | | | 5c. PROGRAM ELEMENT NUMBER |
| 6. AUTHOR(S) | | | 5d. PROJECT NUMBER |
| | | | 5e. TASK NUMBER |
| | | | 5f. WORK UNIT NUMBER |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Department of Energy,Environmental Management,1000 Independence Ave SW,Washington,DC,20585** | | | 8. PERFORMING ORGANIZATION REPORT NUMBER |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) | | | 10. SPONSOR/MONITOR'S ACRONYM(S) |
| | | | 11. SPONSOR/MONITOR'S REPORT NUMBER(S) |
| 12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited** | | | |
| 13. SUPPLEMENTARY NOTES **See also ADM002182. Presented at the AFRL Technology Maturity Conference held in Virginia Beach, VA on 11-13 September 2007.** | | | |
| 14. ABSTRACT | | | |
| 15. SUBJECT TERMS | | | |

| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 18. NUMBER OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
|---|---|---|---|---|---|
| a. REPORT **unclassified** | b. ABSTRACT **unclassified** | c. THIS PAGE **unclassified** | **Same as Report (SAR)** | **16** | |

**Standard Form 298 (Rev. 8-98)**
Prescribed by ANSI Std Z39-18

# What Exactly Does DOE Do?

**The Department of Energy's** overarching mission is to advance the national, economic, and energy security of the United States; to promote scientific and technological innovation in support of that mission; and to ensure the environmental cleanup of the national nuclear weapons complex.

**Energy Security:** Promoting America's energy security through reliable, clean, and affordable energy

**Scientific Discovery and Innovation:** Strengthening U.S. scientific discovery, economic competitiveness, and improving quality of life through innovations in science and technology

**Nuclear Security:** Ensuring America's nuclear security

**Environmental Responsibility:** Protecting the environment by providing a responsible resolution to the environmental legacy of nuclear weapons production

# What Exactly Does EM Do?

The Office of Environmental Management (EM) is responsible for the risk reduction and cleanup of the environmental legacy of the Nation's nuclear weapons program, one of the largest, most diverse, and technically complex environmental programs in the world.

EM is responsible for:

- Cleanup and/or closure of sites.
- Constructing and operating facilities to treat radioactive liquid tank waste into a safe, stable form to enable ultimate disposition.
- Securing and storing nuclear material in a stable, safe configuration in secure locations to protect national security.
- Transporting and disposing of transuranic and low-level wastes in a safe and cost-effective manner to reduce risk.

Annual appropriations are ~ $6-7 B

# DOE Has Its Own GAO Report And May Have Its Own Congressional Language

- Highlights of GAO-07-336, (March 2007) **<u>Major Construction Projects Need a Consistent Approach for Assessing Technology Readiness to Help Avoid Cost Increases and Delays</u>**

- "Of the 12 DOE major projects GAO reviewed … 8 of the 12 projects experienced cost increases ranging from $79 million to $7.9 billion, and 9 of the 12 projects were behind schedule by 9 months to more than 11 years."

- "Even though DOE requires final project designs to be sufficiently complete before beginning construction, it has not systematically ensured that the critical technologies reflected in these designs have been demonstrated to work as intended (technology readiness) before committing to construction expenses."

- "GAO … [recommends improving] DOE's oversight of major construction projects by developing comprehensive standards for measuring and communicating the readiness of project technologies. In developing these standards, DOE should consider lessons learned from the National Aeronautics and Space Administration (NASA) and the Department of Defense (DOD), as well as DOE's limited experience in measuring technology readiness."

# Waste Treatment Involves Chemical Processing

$$\text{Feed} \rightarrow A \rightarrow B \rightarrow C \rightarrow D \rightarrow E \rightarrow \text{Product}$$

| | CHEMICAL INDUSTRY | DOE EM |
|---|---|---|
| **FEED** | Uniform – Well Defined | Poorly Characterized - Variable |
| **OUTPUT** | Uniform – Well Specified | Composition Variable |
| **PREVIOUS EXPERIENCE** | Multiple Plants | One of a Kind |
| **MAINTENANCE** | Hands On | Remote |
| **OPERATIONS** | Hands On | Remote |
| **RECONFIGURATION** | Relatively Easy | Extremely Difficult |
| **PROCESS REFINEMENT** | On the Fly | Extremely Difficult |

Waste Treatment Facilities Must Be Reliable, Robust, Flexible, and Durable

# EM Is Piloting the TRA/AD2 Process

Hanford Waste Treatment Plant (WTP) – The Initial Pilot Project (November 2006)

- The first set (3) of TRAs
- The first (and only) Technology Maturation Plan

Hanford Low Activity Waste Treatment Business Case Evaluation

- A determination of the costs and schedule implications of choices for various treatment options for low activity waste (LAW)

Savannah River Site Tank 48 Treatment Down Select

- TRAs conducted for two treatment technologies to aid in the down selection of a treatment for the waste in tank 48

Hanford K Basins Sludge Treatment Process

- Determination of readiness of process for implementation

# Hanford LAW Treatment Business Case Evaluation

WTP can only treat ~ ½ of the LAW in the time it will take to treat all the HLW.

- There is a need for tank space that will get more urgent with time.
- The single shell tanks are past their lifetime. Some have already leaked. Double shell tanks will be well beyond their lifetime before HLW treatment is completed

DOE examined technology options that involved:

- Supplementing the LAW Vitrification Facility capacity.
- Starting the LAW Facility before the WTP Pretreatment and High-Level Waste (HLW) Vitrification Facilities are available (Requires tank farm pretreatment capability)

TRAs were carried out on three LAW immobilization processes and three pretreatment technologies. The cost and schedule to advance each technology to TRL 6 was estimated.

# Savannah River Site Tank 48 Treatment Down Select

- Tank 48H in Savannah River Site (SRS) contains tetraphenylborate (TPB) from the operation of an In-Tank Precipitation (ITP) process. TPB is not compatible with SRS HLW treatment processes and must be removed or destroyed before the tank can be used

- Compared technology readiness of Fluidized Bed Steam Reforming and Wet Air Oxidation for treatment of Tank 48H tetraphenylborate legacy waste.
  - Defined CTEs
  - Assigned TRLs
  - Assessed Advancement Degree of Difficulty (cost and schedule required to reach TRL 6)

# Methodology

- Followed the WTP example
- Used WTP definitions for TRLs
- Used independent experts
- Used the Calculator
- Modified some Calculator questions
- Added process questions.

# TRL Working Definitions

- **Scale**
  - Full Plant Scale — Matches final application
  - Engineering Scale — Typical (1/10 < system < Full Scale)
  - Laboratory/Bench Scale — < 1/10 Full Scale

- **System Fidelity**
  - Identical System Configuration - matches final application in all respects
  - Similar System Configuration - matches final application in almost all respects
  - Pieces - System matches a piece or pieces of the final application
  - Paper - System exists on paper - no hardware system

- **Environment (Waste)**

| | |
|---|---|
| Operational (Full Range) | Full range of actual waste |
| Operational (Limited Range) | Limited range of actual waste |
| Relevant | Simulants + a limited range of actual wastes |
| Simulated | Range of simulants |

# TRL Testing Requirements

| TRL Level | Scale of Testing | Fidelity | Environment |
|---|---|---|---|
| 9 | Full | Identical | Operational (Full Range) |
| 8 | Full | Identical | Operational (Limited Range) |
| 7 | Full | Similar | Relevant |
| 6 | Engineering/Pilot Scale | Similar | Relevant |
| 5 | Lab/Bench | Similar | Relevant |
| 4 | Lab | Pieces | Simulated |
| 3 | Lab | Pieces | Simulated |
| 2 | | Paper | |
| 1 | | Paper | |

# Additional Process Chemistry Questions

| TRL | Criteria |
|---|---|
| 5 | The range of all relevant physical and chemical properties has been determined (to the extent possible) |
| | Simulants have been developed that cover the full range of waste properties |
| | Testing has verified that the properties/performance of the simulants match the properties/performance of the actual wastes |
| | Laboratory scale tests on the full range of simulants using a prototypical system have been completed |
| | Laboratory scale tests on a limited range of real wastes using a prototypical system have been completed |
| | Test results for simulants and real waste are consistent |
| | Laboratory to engineering scale scale-up issues are understood and resolved |
| | Limits for all process variables/parameters are being refined |
| | Test plan for prototypical lab scale tests executed – results validate design |
| | Test plan documents for prototypical engineering scale tests completed |

| | | | | | |
|---|---|---|---|---|---|
| | Characterization | | Testing | | Process limits |
| | Simulants | | Scale up issues | | Test plans |

# What We've Learned About The TRA/AD2 Process (1)

- Structured, objective, and clearly documented process ("transparent").
- The process enforces discipline on DOE and the Contractor.
- Contractors and DOE like the TRA language and formalism. Technical communication is greatly improved.
- Technologists like having standards.
- Documentation is critical
- Useful tool for comparing candidate technologies.
- Process assists in identification of specific actions needed to reduce programmatic risk to final commitment and major investment in a technology.

# What We've Learned About The TRA/AD2 Process (2)

- Relevant environment (feed characterization) is critical
- Product definition/requirements are critical (DOE must do its part)
- All components must be tested, preferably in a complete system
- The calculator is useful to focus discussion on key areas
- Evaluation of process flow, connecting the technologies in a flowsheet, remains a challenge.

# Next Steps

- Determine whether the  process is to be required/adopted by EM and/or DOE
- Develop program guidance for TRAs, TMPs, IRPs, Test Plans
- Formalize definitions and embed them in the culture
- Tie process to DOE/EM project management/acquisition strategy
- Connect process to DOE/EM risk evaluation policy
- Continue to wrestle with chemical process flow
- Disseminate information on process and train facilitators.

# DOE Critical Decision Process

CD-O: Approve Mission Need

A Program identifies a credible performance gap between its current capabilities and capacities and those required to achieve the articulated in its strategic plan goals. Approval of CD-0 formally establishes a project and begins the process of conceptual planning and design used to develop alternative concepts and functional requirements.

CD-1: Approve Alternative Selection and Cost Range

CD-1 approval marks the completion of and provides the authorization to begin the project Execution Stage, allowing Project Engineering and Design funds to be used. For design-build projects an RFP may be prepared and long- lead procurements may be approved.

CD-2: Approve Performance Baseline

A performance baseline is developed based on a mature design, a well-defined and documented scope, a resource-loaded detailed schedule, a definitive cost estimate and defined Key Performance Parameters. A budget request is submitted for the total project cost.

CD-3: Approve Start of Construction

Approval of CD-3 authorizes the project to commit all resources necessary, within the funds provided, to execute the project.

CD-4: Approve Start of Operations or Project Completion